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Race on for UCAR

Armed and autonomous: unmanned rotorcraft target US Army

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TEAM TACTICS

Simulations suggest that armed autonomous unmanned rotorcraft can co-operate effectively wth manned helicopters

GRAHAM WARWICK / WASHINGTON DC

Two years ago, the idea of armed, unmanned rotorcraft teaming with manned helicopters to locate and attack targets seemed far-fetched. The concept remains a challenge but, after two phases of its Unmanned Combat Armed Rotorcraft (UCAR) technology demonstration, the US Defense Advanced Research Projects Agency (DARPA) believes there are compelling benefits.

Proof that manned/unmanned teaming works exists only in simulations so far but, if the US Army agrees to fund the programme's later phases, flying UCAR demonstrators should determine the concept's feasibility and usefulness by the decade's end. DARPA is confident, as the just-ended 15-month second phase exceeded expectations. "The teams accomplished more than they were expected to with limited time and money," says programme manager Don Woodbury.

The UCAR's autonomy allows manned/ unmanned teams to co-operate

Groundwork laid

This month, army funding permitting, DARPA will choose either Lockheed Martin or Northrop Grumman to proceed into the 30-month third phase of the programme, building two A-model air vehicles to demonstrate key aspects of their UCAR system. "We have laid the groundwork for Phase 3, and shown that the challenging goals look achievable within the timeframe and resources," says Woodbury.

If the programme proceeds, Phase 3 will be followed by a fourth, system-maturation, phase during which a B-model prototype with 60-80% of the capability of an operational UCAR will be built. The programme will then transition to the US Army in 2009 in preparation for a decision on development. "The first operational UCARs could be fielded in 2012," says Woodbury.

At the heart of the UCAR concept is technology enabling autonomous operation and collaborative execution by teams of unmanned and manned aircraft. Autonomous collaboration means the unmanned rotorcraft can operate independently of human control, while co-operating with other UCARs and manned aircraft to accomplish the mission.

In prior attempts at manned/unmanned teaming, the workload in controlling the unmanned vehicles "consumed" the human crew, turning the manned aircraft into a dedicated command and control (C2) platform. Autonomous collaboration, the Phase 2 simulations showed, allows the manned aircraft to command the UCARs and also do its own mission. "The manned aircraft is not taken out of the fight," says Woodbury. "Autonomy, team-based interaction, verbal interface and distributed command and control lead to workload reduction." Compared with the DARPA/US Air Force/US Navy Joint Unmanned Combat Air Systems programme, UCAR takes vehicle autonomy to the next level, says Woodbury. Left to their own devices, the UCARs will co-operate in the same way as manned aircraft, he says. "Manned aircraft overlap their sensors and weapons, cover each other and relay communications. A team of unmanned vehicles brings the same benefits," he adds.

According to Northrop Grumman, autonomy enables engagement options such as "protect self", in which the UCAR will avoid or engage threats to itself; "protect team", where it will engage threats to any UCAR and sacrifice itself to protect the manned aircraft; and "protect friendlies", in which the vehicle will engage threats to friendly forces.

The air mission commander – the co-pilot/gunner in the front seat of a Boeing AH-64D Apache in the Phase 2 simulations – interacts with the unmanned rotorcraft not as an individual but as a team. "The UCARs nominate a team lead to act as the focal point for interaction with the manned aircraft," says Woodbury. The team lead can change as the mission unfolds, as was demonstrated in Phase 2. "If an aircraft had to go back, it seamlessly passed the role to another."

Other members of the team take the lead in other functions, including interfacing with external information systems and making the data available to the team. UCARs will take information from the Multi-sensor Command and Control Aircraft (MC2A) or the Global Information Grid. "They can also push information back into the common operating picture, and that is powerful," says Greg Zwernemann, Northrop Grumman programme director. In Phase 2, by linking its UCAR and MC2A simulations, the company was able pass radar data from the manned surveillance aircraft to the unmanned rotorcraft team.

Woodbury says team-based interaction allows the human commander to work with the unmanned rotorcraft in the same way as with another pilot: planning the mission, setting the constraints and rules of engagement, and parcelling out the top-level tasks. In the air, the commander supervises the UCARs, taking the weapon release decisions, while monitoring his own sensors and employing his own weapons.

Voice command

Phase 2 simulations showed the benefits of verbal interaction with the unmanned rotorcraft using voice commands and spoken responses. "The commander talks to the UCAR; the UCAR talks back," says Woodbury. "The commander will tell the UCAR to fly to Area Red, do a recce, do not fire unless fired on, report back at a specific time, and stay within this airspace. The UCAR will find and identify a target, pass the information back to the human, replan the mission, get a decision from the human, and execute."

The commander is always in the decision loop, but does not have to approve every action the team takes. If a UCAR picks up a threat the rules of engagement say to avoid, the team will replan the mission to achieve the objective and send the new plan to the commander for approval. "The commander has X amount of time to review and approve the plan or it is implicitly approved," says Woodbury. "The human pilot is going to get busy and the UCAR will not hover, looking for something to do."

In Phase 2, as part of its workload-management system, Lockheed Martin demonstrated "negotiated intervention", the UCARs negotiating with the manned aircraft so that high-priority alerts took precedence over lower-priority messages. "We demonstrated tactile-vest alerting," says programme director Dan Rice. "The operator gets frequency, intensity and directionality cues that improve situational awareness and indicate which UCAR has an alert and how important it is," he adds.

To achieve the goals of finding concealed and camouflaged targets and differentiating between combatants and non-combatants, the UCAR carries five different sensors, including millimetre-wave radar for syn-

Intermeshing rotor (Northrop Grumman, *top*) is pitted against compound helicopter (Lockheed Martin, *bottom*)

BARCLAY SHAW OF SHAW GRAPHICS

thetic-aperture radar (SAR) ground imaging and moving-target indication (MTI); electronic support measures for emitter identification; electro-optical/infrared (EO/IR) for targeting; ladar (laser radar) for target identification; and a laser rangefinder/designator.

"The sensors are highly integrated, and multi-spectral, to pull targets out of the clutter," says Woodbury. As every vehicle has the same sensor capability, the team can get multiple looks at a target. "It is not just multi-sensor fusion on a single UCAR, it is also fusion with other members of the team," says Zwernemann.

Using multi-sensor fusion and automatic target recognition (ATR), the unmanned rotorcraft will send target-image "chips" to the mission commander, who can then request additional information, including streaming video. DARPA is not investing in new sensor or ATR development for UCAR, but is taking advantage of hardware and software research under way elsewhere. Simulations were used during Phase 2.

Flying ahead

To be effective, the UCAR must be able to fly autonomously at low altitude, day or night, avoiding obstacles and evading threats. The unmanned rotorcraft must also be survivable, so that it can be "the point of the spear", says Woodbury – flying ahead of the manned helicopter, higher than a human crew dare go, to get a wider view of the battlefield, and also closer to the threat so that its sensors can find and identify concealed targets and distinguish civilians from soldiers.

In Phase 2, DARPA completed preliminary design of an obstacle avoidance system (OAS) – a three-beam ladar providing 360° spherical situation awareness. Lasers operating at 1.06µm, 1.3µm and 1.5µm wavelengths produce very short pulses for high range resolution, says Woodbury, and can detect wires at 400m (1,300ft) and aircraft at 1km (1.6m). Northrop Grumman and laser developer Fibertech are under contract to build a brassboard system for flight testing next year on a surrogate aircraft.

Also in Phase 2, both teams built pole models of their UCAR designs for signature measurement. Some tests were conducted with rotors turning. "Survivability is a challenging problem," says Woodbury. The UCAR is designed to be survivable at altitudes ranging from "hundreds of feet to thousands of feet", requiring a "holistic" approach to survivability, he says. "Self-awareness" will enable the vehicle to detect and identify threats. A distributed-aperture system – using uncooled IR sensors providing broadband 360° coverage – will detect gunfire, missile plumes and grenade launches. The onboard mission management system will react autonomously to threats. "The UCAR will not just sit there are become a target," says Woodbury.

DARPA has set goals of a $4-8 million flyaway cost, including payload, and operating and support (O&S) costs 10-40% less than the Apache's. At their preliminary design reviews earlier this year, both teams were well with the unit and O&S cost goals, says Woodbury. "We pretty much buy aircraft by the pound, but there is potential to make a big dent in the high O&S costs," he adds.

While UCARs will be flown at a high operational tempo in wartime, in peacetime there will be opportunity to reduce utilisation and store some of the vehicles. "We will need to fly enough so that manned systems and commanders on the ground can gain confidence in using UCAR, so we will operate some percentage but not 100%," Woodbury says. Prognostic health management, contractor total system support and two-level user/manufacturer maintenance will reduce O&S costs.

In Phase 2, the two teams "successfully differentiated themselves", says Woodbury. Northrop Grumman's concept involves a platoon of up to six air vehicles: two scout UCARs flying at higher altitude to provide wide-area search and communications relay; and four attack UCARs flying at lower altitudes to identify and engage targets.

"The scout UCAR looks ahead using SAR/MTI, while the attack UCAR uses EO/IR and ladar to target and execute using onboard weapons," Zwernemann says, adding: "The two scouts have different look angles and fuse the information to improve target identification." The UCARs are identical and interchangeable. "If an attack vehicle runs out of weapons, it can change roles with a scout vehicle."

Team flexibility

Lockheed Martin's concept uses existing wide-area surveillance assets to support a basic four-UCAR team. "The unit is not a fixed size," says Rice. The size depends on the mission objectives, and could range from a lone UCAR to multiple teams.

Lockheed Martin, working with Bell, is proposing a compound helicopter with propulsive anti-torque system – a high-bypass propulsion system in the tailcone that eliminates the tailrotor while providing forward thrust, giving a dash speed exceeding 180kt (335km/h). The rotorcraft is derived from Bell's Model 407 commercial helicopter, with advanced cambered rotor blades. Northrop Grumman, working with Sikorsky and Kaman, is proposing an intermeshing-rotor design that eliminates the tailrotor and delivers all the power to the rotors for lift, says Zwernemann. Derived from Kaman's K-Max external-lift helicopter, the vehicle has a new rotor aerofoil, blade servo-flap and forward-tilted mast to increase thrust and reduce drag, pushing speed above 160kt.

Lockheed Martin's UCAR has a gross weight of 2,500kg (5,500lb), payload of more than 317kg and an endurance of over 9.5h; Northrop Grumman's has a gross weight of 2,890kg carrying four Hellfire missiles, payload of 1,135kg internally or 1,450kg externally, and 10.6h endurance with auxiliary fuel. Both are powered by a single LTHEC T800 turboshaft.

While DARPA insists UCAR is not an air-vehicle programme, it would advance military-rotorcraft technology in the wake of the US Army's cancellation of the Boeing Sikorsky RAH-66 Comanche.

The latter's demise may have created an opportunity for a survivable platform like the UCAR to provide armed reconnaissance for the Apache, Rice says. "With the cancellation of Comanche, UCAR is more important than ever," says Zwernemann. "UCAR provides additional capability without putting the Apache at risk." ■

LOCKHEED MARTIN UCAR CONCEPT